

# **HONDA** Rollover Resistance



## **Honda Recommended Rollover Test Procedures**

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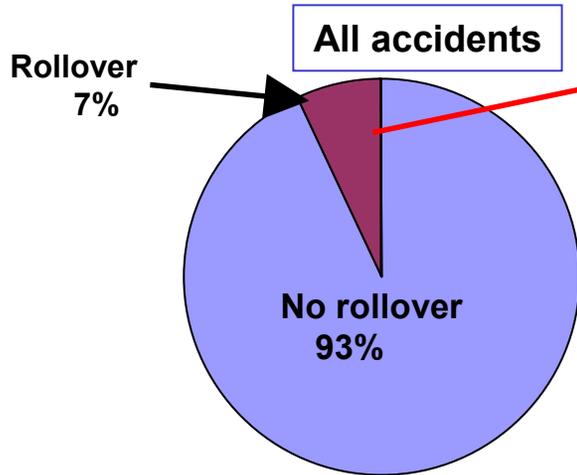
# **HONDA** Rollover Resistance

## Contents

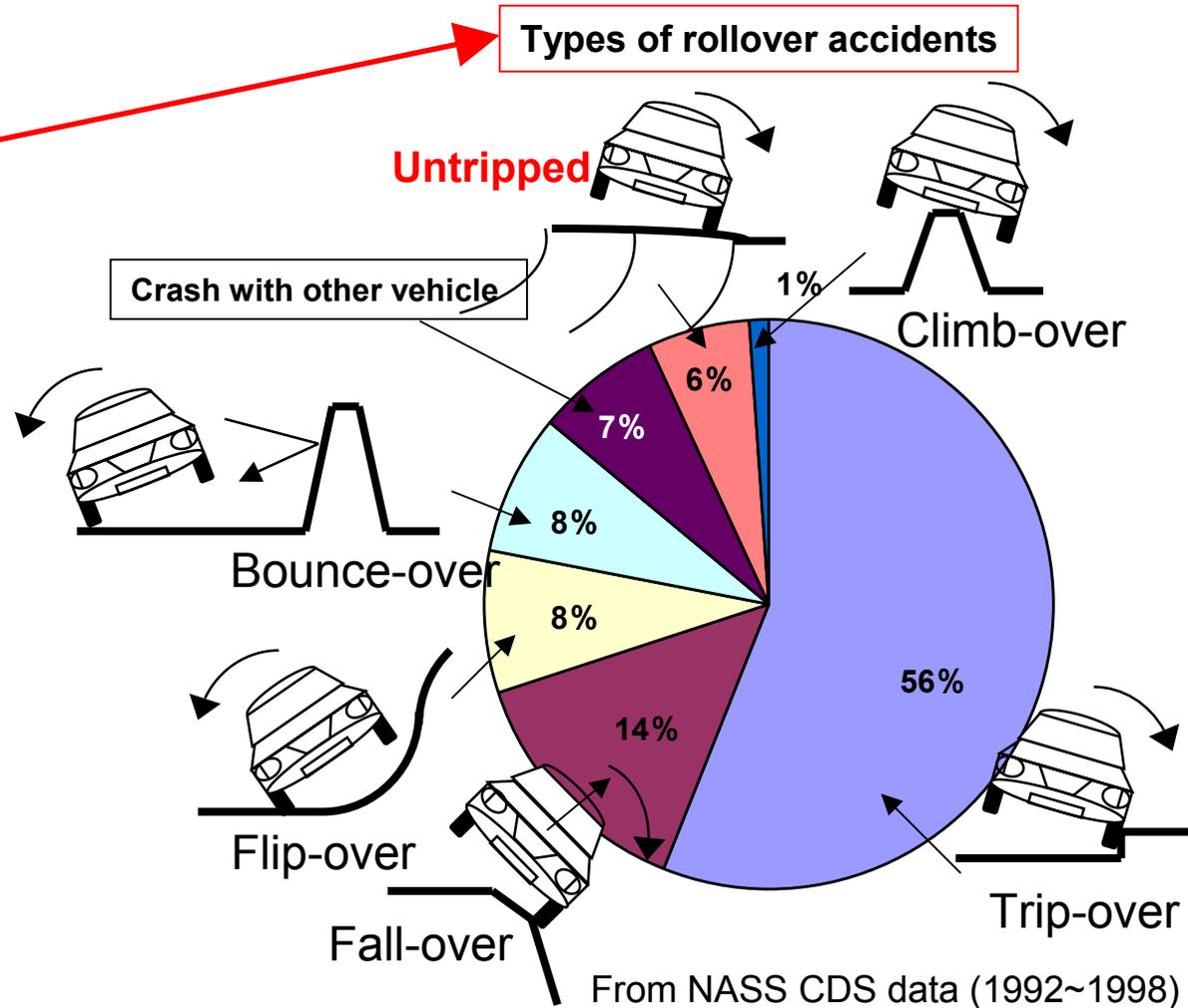
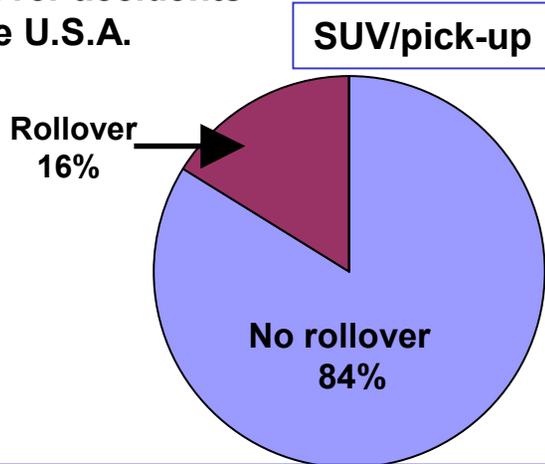
- 1. Crash Statistics**
- 2. Summary of Comments Already Received by NHTSA**
- 3. Comparison of Proposed Test Methods**
- 4. Statement of Honda's Basic Policy**
- 5. Honda's Stance on the TREAD Act**
- 6. What is New about Honda's AVC Reverse Steer Test?**
- 7. Final Comments**

# HONDA Rollover Resistance

## 1. Crash Statistics



### Rollover accidents in the U.S.A.



- Although rollover comprises 7% of all the accidents, in the categories of SUV's and pickups, the percentage jumps up to 16%.
- Trip-over accounts for more than 50% of rollover accidents. Untripped rollover is 6%.
- Both static (tripped) and dynamic (untripped) rollovers are important.

# HONDA Rollover Resistance

## 2. Summary of Comments Already Received by NHTSA

	VDA Course (ISO 3888 Part 2)	Centrifuge, Sled, Side Pull	Fishhook	Dynamic Weight Transfer Method
Organizations Supporting	Toyota (tripped) Mitsubishi VW BMW DaimlerChrysler Continental Teves	Centrifuge: UMTRI GM (w/ Stability Margin and Min Lateral Accel) AHAS Public Citizen Consumers Union (as SSF substitute)  Side Pull: H-D  Sled: Exponent (Dynamic Rollover Test)	Nissan Toyota (untripped) TRW Chassis	Ford
Method	<ul style="list-style-type: none"> <li>- Driver controlled steering</li> <li>- Defined path, turning from right lane to left lane and back to right lane</li> <li>- Tight lane widths</li> <li>- Entry speed incremented from run to run</li> <li>- Metric: entry speed, behavior at limit (plow, spin, roll)</li> </ul>	<ul style="list-style-type: none"> <li>- Done with centrifuge, side pull, or sled apparatus</li> <li>- Tires blocked to prevent sliding, vehicle tethered</li> <li>- Apparatus accelerated until rollover occurs</li> <li>- Metric: lateral acceleration at rollover</li> <li>- Other variations to simulate effects of roll momentum</li> </ul>	<ul style="list-style-type: none"> <li>- Done with AVC</li> <li>- + 270/-600 deg SWA</li> <li>- 720 deg/sec steering rate</li> <li>- Reversal timing determined according to pretests (Nissan)</li> <li>- Entry speed incremented from run to run</li> <li>- Metric: entry speed, lateral accel at rollover (Toyota)</li> </ul>	<ul style="list-style-type: none"> <li>- Done with path following AVC</li> <li>- A group of defined double lane change paths, encompassing a range of frequencies</li> <li>- 45 mph, 0.7 g</li> <li>- Metric: maximum percent weight transfer over a specified minimum duration</li> </ul>

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## 3. Comparison of Proposed Test Methods

Objectives	Method		
	Laboratory Device (e.g., Centrifuge)	Defined Steering (e.g., AVC-controlled Fishhook)	Defined Path (e.g., VDA course)
Direct connection to tripped rollover, explores excitations beyond range of tire-pavement friction	○	X	X
Direct connection to untripped rollover	X	○	○ (depends on vehicle)
Repeatable	○	○	X
No need to control pavement friction and tire wear characteristics	○	X	X
Includes effects of roll momentum	X	○	○ (for some vehicles)
Identifies "worst case" for each vehicle	○ (tripped only)	○ (untripped only)	X
Easy for consumer to understand ("face validity")	X	○ (Honda method)	○

# HONDA Rollover Resistance

## 3. Comparison of Proposed Test Methods (Cont'd)

Objectives	Method		
	Laboratory Device (e.g., Centrifuge)	Defined Steering (e.g., AVC-controlled Fishhook)	Defined Path (e.g., VDA course)
International acceptance as a "handling" test procedure	X	X	○
Measures effects of ESC systems (yaw or roll)	X	○	○
Tire cannot be "detuned" to "pass" this test.	○	X	X
Easy and low cost testing	X	X	○
Is insensitive to vehicle size	○	○	X

It is difficult to find a single method which meets all objectives.

# HONDA Rollover Resistance

## 4. Statement of Honda's Basic Policy:

Provide safer products (vehicles) to customers

“using the technologies that Honda has”

**No manufacturer can guarantee that a vehicle will not rollover by itself due to its own maneuvers.**

### Honda's policy of suspension functions against rollover

1. The vehicle shall not roll over by itself from steering inputs which can **realistically** occur in **real world situations**. (untripped rollovers)
2. Consideration shall be given to reducing the likelihood of rollover caused by an exterior factor or secondary factor. (tripped rollovers)

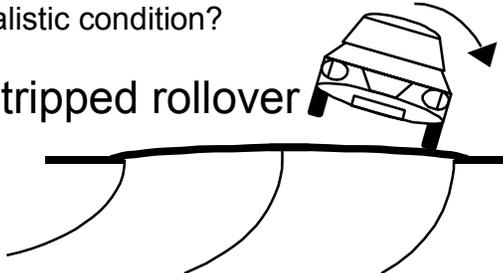
#### Suspension functions

Direct

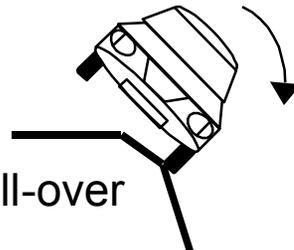
Indirect

Rollover shall not occur under a realistic driving condition. How do we distinguish a realistic condition from an unrealistic condition?

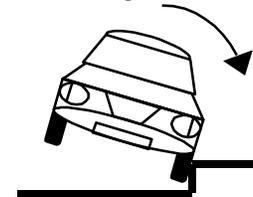
Untripped rollover



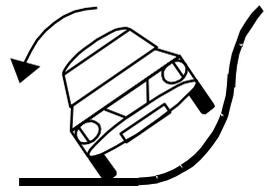
Fall-over



Trip-over



Flip-over



Improvement in steering performance and stability, etc. makes it less likely that the following conditions will occur.

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## 5. Honda's Stance on the Tread Act

We think that the following requirements are necessary to provide consumers with the most relevant, reliable, and useful information regarding rollover resistance performance.

- It shall be realistic.
- It shall be objective.
- It shall be fair.
- It shall have a superior repeatability.

It may be difficult to meet all of the above requirements completely, but we will support and propose the best methods available at the current time.

### Test methods that Honda supports and proposes

- (1) Honda supports evaluation of the steady state limit lateral acceleration by the proposed Centrifuge Method.
- (2) Honda proposes a dynamic evaluation by a reverse steer test using an automatic steering device (AVC Reverse Steer Test).

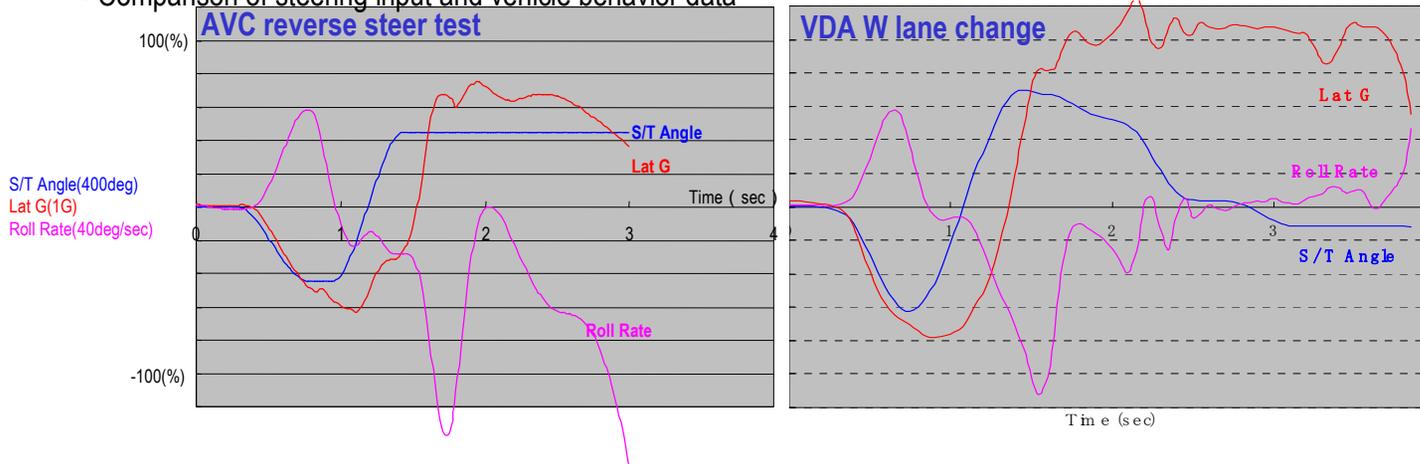
# HONDA Rollover Resistance

## Honda's experience with the VDA Double Lane Change Test

**Honda believes that the VDA Mode can be useful for vehicle development but is not appropriate for NHTSA to rate vehicles for rollover resistance.**

We found that for some medium sized SUV's, the VDA Double Lane Change Test can give similar results to our AVC Reverse Steer Test. Our biggest concern would be repeatability.

- Comparison of steering input and vehicle behavior data



The steering reversal timing and roll rates are very similar

However, we also found that for larger vehicles, it was difficult to maneuver through the course and we could never approach the worst case for rollover.

**What will the criteria be for the VDA Mode? Consider this case:**

**Vehicle A: Entry Speed: 32 mph, Limit Condition: plows out into cones**

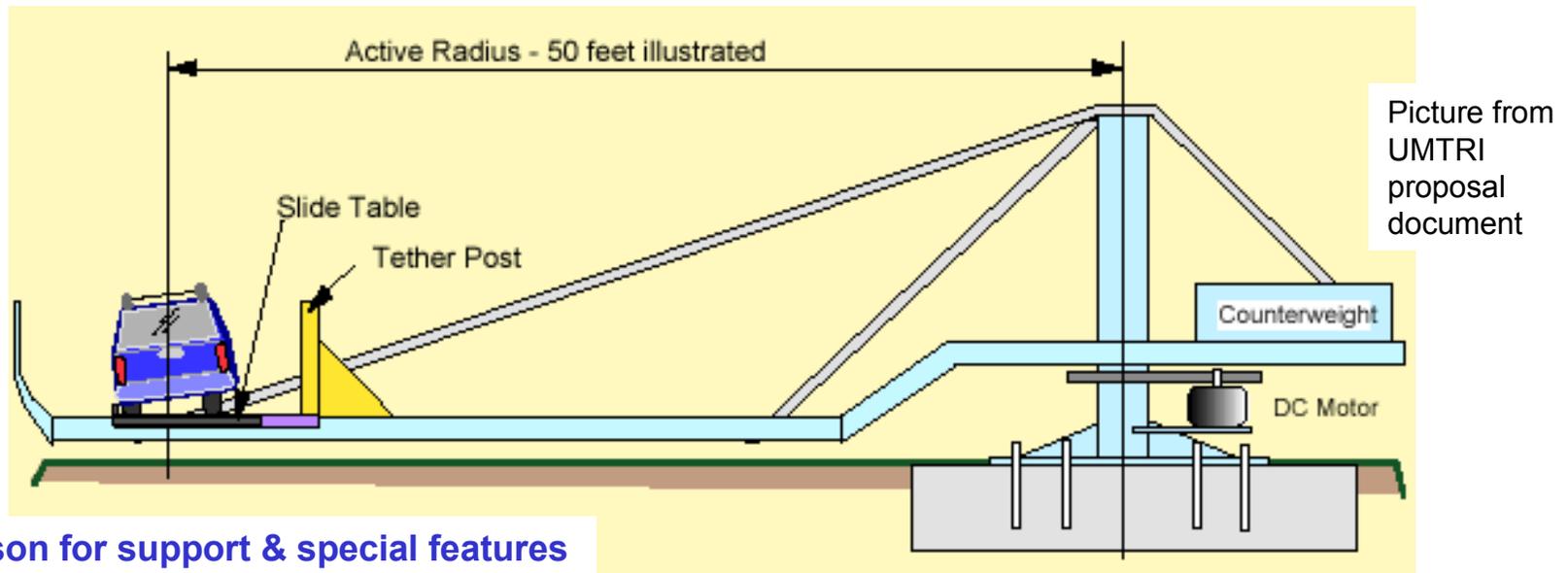
**Vehicle B: Entry Speed: 38 mph, Limit Condition: rolls over**

**Which vehicle is worse?**

# HONDA Rollover Resistance

(1) Honda supports evaluation of the steady state limit lateral acceleration by the proposed Centrifuge Method.

This is a method advocated by the University of Michigan (UMTRI) and GM. It requires the vehicle to be placed on a turntable (arm), which is like a centrifugal separator, and provides lateral acceleration by rotating the turntable. The acceleration which causes the inner wheel loads to be reduced to zero is deemed the steady state limit lateral acceleration.



## Reason for support & special features

- Center of gravity movement due to steady state tire and suspension deflections (including the effects of suspension jacking) are reflected. Therefore, this method is more similar to what occurs dynamically than SSF or other static methods.
- Because it is not an actual driving test, there is no need to specify or control the road surface friction, tire condition, etc.
- Simulation can be done relatively easily. Some parameters that are relatively difficult to obtain (e.g., tire properties, moments of inertia) are not required. This helps to enable evaluation at the vehicle design stage.

Honda does not support variations of the Centrifuge Method proposed by UMTRI.

# **HONDA** Rollover Resistance

Other comments on GM's proposal

**GM proposal does not fully measure rollover resistance**

- Does not take roll momentum into account
- Does not measure effects of ESC systems

**Maximum Lateral Acceleration test**

- Honda uses a maximum lateral acceleration test internally, but we do not support this test for use in an NCAP rating system
  - It does not sufficiently characterize the vehicle's handling capabilities or the likelihood of the vehicle leaving the roadway

**Stability Margin**

- We do not support the stability margin concept
  - Difficult for consumers to understand
  - Requires mixing Centrifuge (static) results with on-road (dynamic) results

**Rating Method (5 star)**

- We do not support the GM proposal
  - We do not have any data to evaluate GM's proposed rating criteria

# HONDA Rollover Resistance

(2) Proposal of reverse steer test by the automatic steering device (AVC Reverse Steer Test)

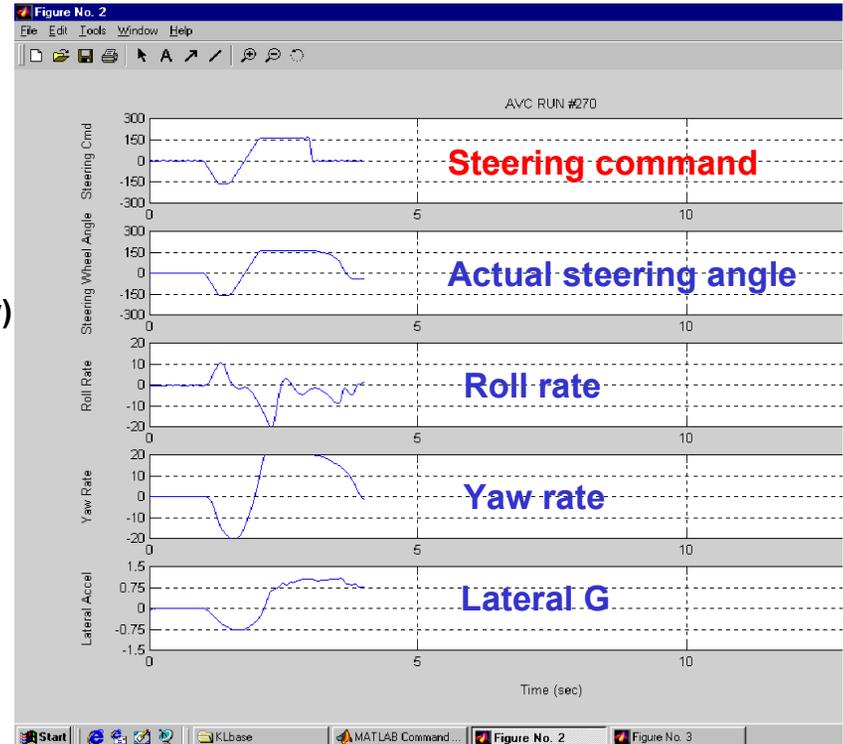
- Setup of the automatic steering device



- Preliminary tests (Ramp steer, roll natural frequency)  
- Input of reverse steer test parameters  
- Test (Primary confirmation of rollover occurrence/non-occurrence, data collection)



- Analysis of steering input, vehicle behavior data  
(Secondary confirmation of rollover/non-rollover)

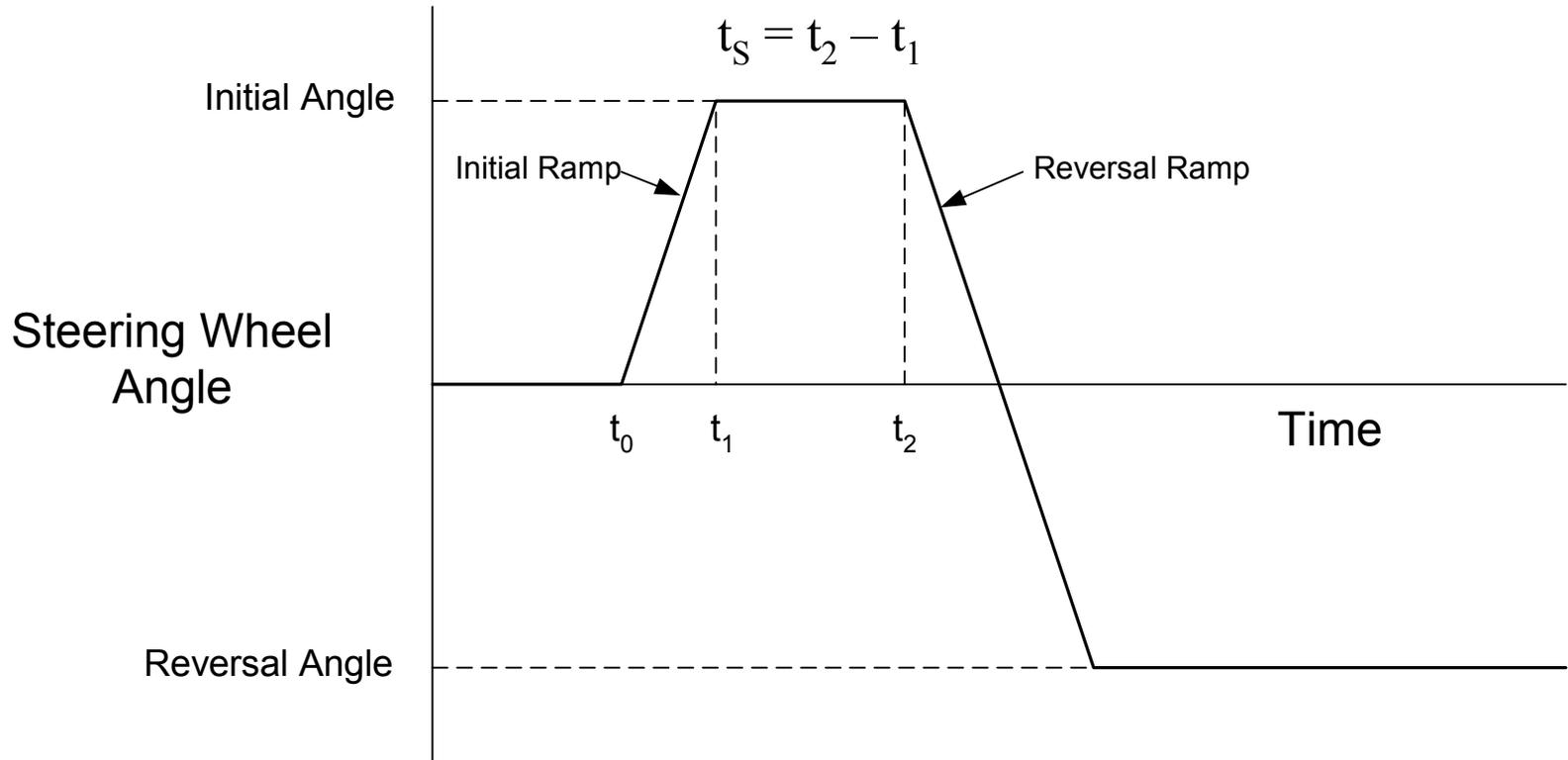


## Special features

- The determination of steering reversal timing is made according to an algorithm that uses real time sensor feedback to maximize the effects of roll momentum. This results in superior objectivity and fairness.
- Due to the automatic steering device, it has superior repeatability. (However, the road surface friction and tire condition need to be controlled.)
- It can duplicate a realistic worst-case condition with human limits (maximum steering angle, maximum steering rate) and appropriate vehicle speed (70 kph is reasonable).

# HONDA Rollover Resistance

## 6. What is New About Honda's AVC Reverse Steer Test?



# HONDA Rollover Resistance

## Comparison of NHTSA and Honda Fishhook Tests

Test Parameter	NHTSA #1 (current)	NHTSA #1 (proposed)	NHTSA #2 (proposed)	NHTSA #3 (proposed)	Honda-DRI	Possible New Method
Steering Rate (deg/sec)	Variable, based on roll natural freq meas (not successful, used 750)	720	? 720	? 1000	720	720
Initial Peak Angle (deg)	270	Determined by equal value of lat accel (unknown value)	? Determined by equal value of lat accel (unknown value)	? 250	Determined by equal percentage of peak lat accel (pretests)	Determined by equal percentage of peak lat accel (pretest at 60 kph)
Reversal Peak Angle (deg)	600	600	? 600	? 500	Same as initial peak angle	Same as initial peak angle
Reversal Determination	Variable timing based on roll natural freq measurement (not successful used 0.25 sec)	Fixed timing (unknown value)	At 1 <sup>st</sup> roll rate zero crossing	Fixed timing based on pretests involving 3 <sup>rd</sup> roll rate zero crossing	At 2 <sup>nd</sup> peak value of roll rate for each test	At 2 <sup>nd</sup> peak value of roll rate for each test
Run-to-run Increment	Speed	Speed	Speed	Speed	Steering wheel angle	Speed (start at 60 kph)

# **HONDA** Rollover Resistance

## Comparison of NHTSA and Honda Fishhook Tests (Cont'd)

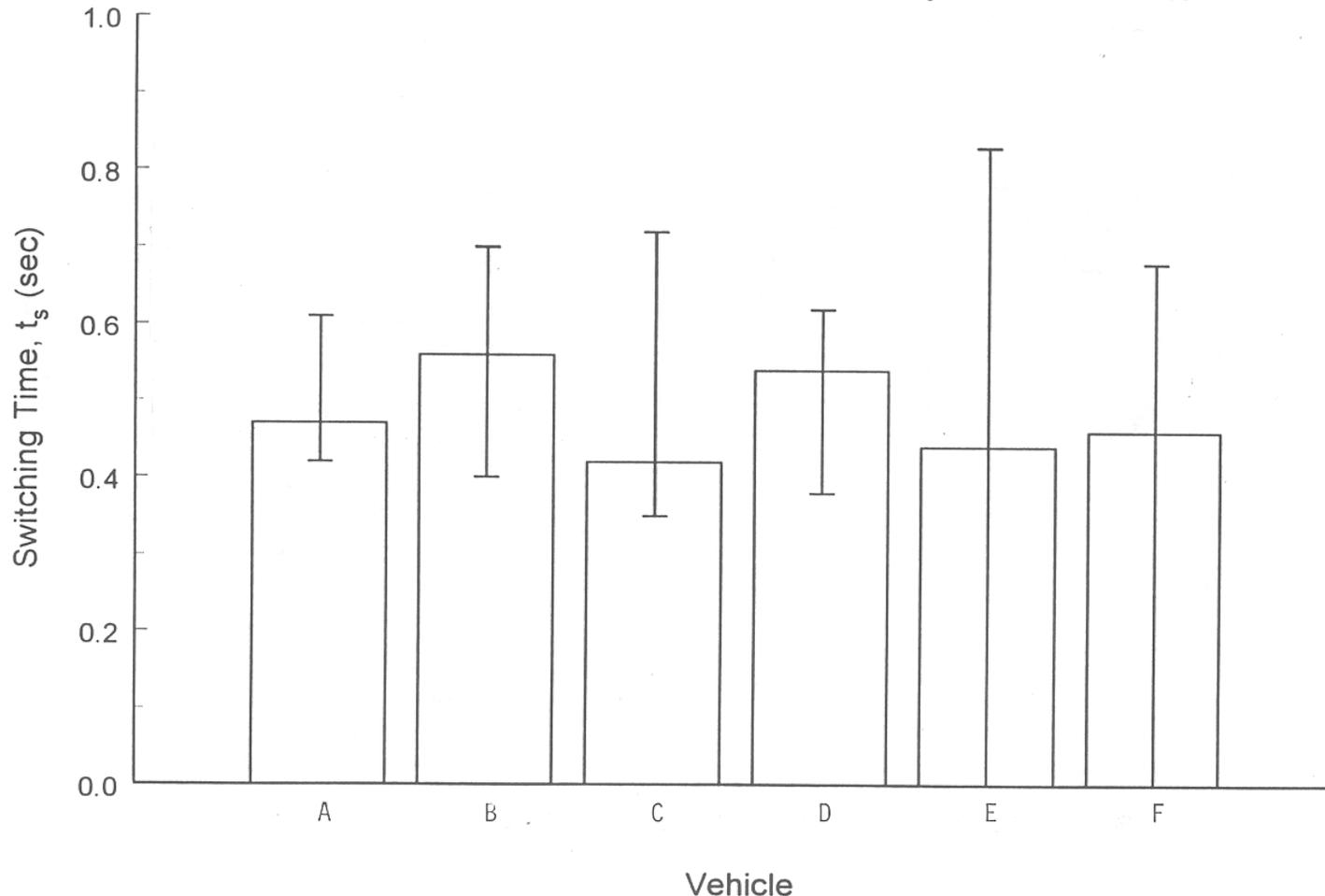
- **Areas of agreement**
  - **Basic form of test**
  - **AVC required**
  - **Selection of initial steering angle must consider steering gain**
  - **Importance of roll momentum timing**
  - **Steering rates (generally)**
- **Areas of difference**
  - **Reversal timing**
  - **Selection of initial and reversal steering angle magnitudes**

# HONDA Rollover Resistance

## Measured Effect of Reversal Timing

Note: Bars indicate the  $t_s$  which resulted from the AVC algorithm (Mode 12).

Vertical lines indicate the range of  $t_s$  which resulted in outrigger touch.



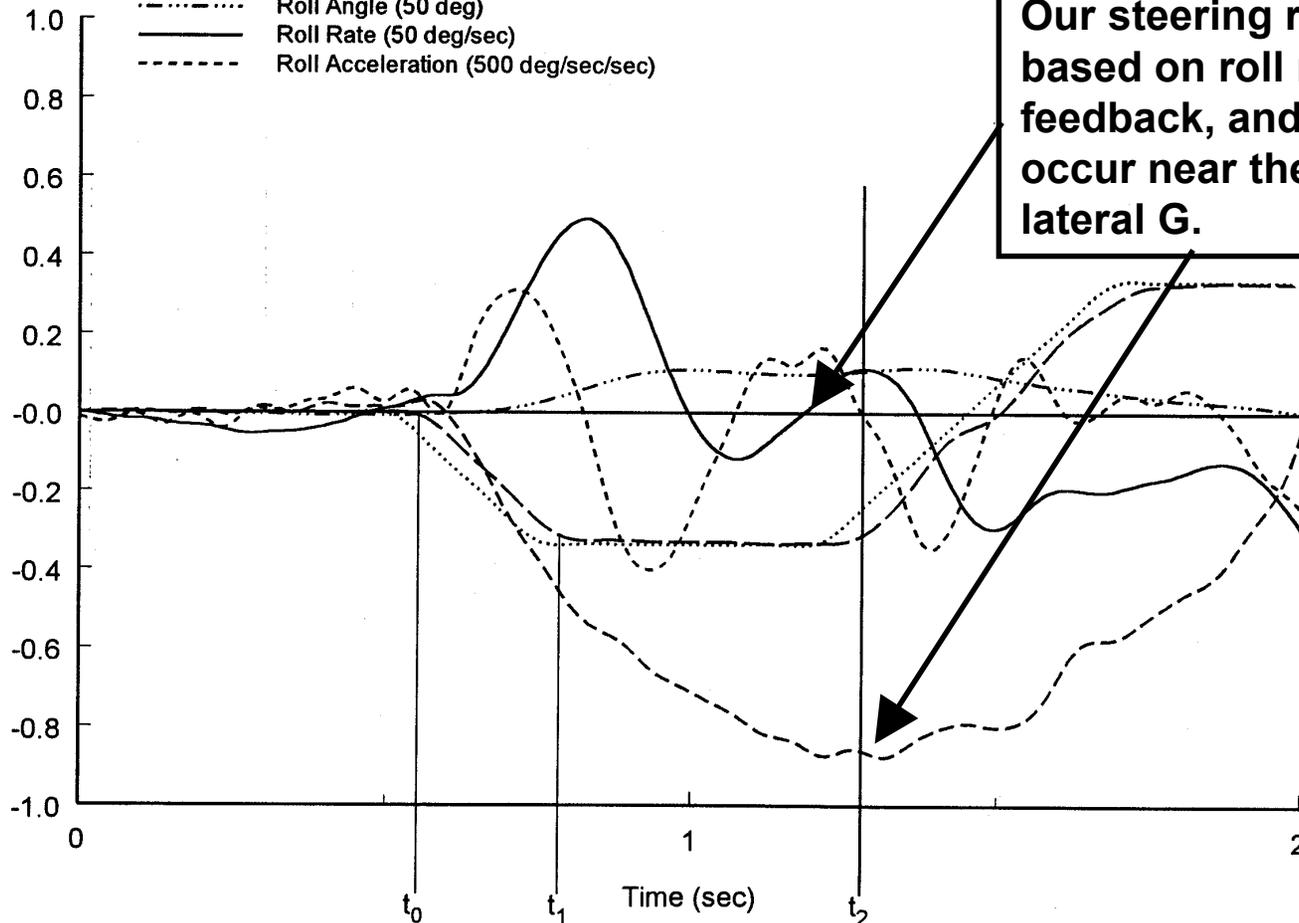
Our experience has shown that an appropriate reversal timing would be around 0.5 sec for many SUV's, but may be different for each vehicle.

# HONDA Rollover Resistance

## Example of Reversal Timing for Honda AVC Reverse Steer Test

### Y Axis Scale Factors

- Variable (scale factor/unit)
- SW Angle (500 deg)
- ..... Commanded SW Angle (500 deg)
- - - Lateral Acceleration (1 g)
- · · · · Roll Angle (50 deg)
- Roll Rate (50 deg/sec)
- - - - - Roll Acceleration (500 deg/sec/sec)



# HONDA Rollover Resistance

## 7. Final Comments

1. **As an evaluation of the basic characteristics of steady state dynamic stability and resistance to rollover caused by external secondary factors,**
  - (1) Honda supports evaluation of the steady state limit lateral acceleration by the proposed Centrifuge Method.
  
2. **To evaluate the resistance to untripped rollover for realistic steering inputs which may actually occur in the real world,**
  - (2) Honda proposes a dynamic evaluation by a reverse steer test using an automatic steering device (AVC Reverse Steer Test).

**Honda is proposing both 1 AND 2 above, and both methods need to be considered at the time of evaluation.**

### Supplementary information

#### ESC

We understand that electronic stability control (ESC) may affect rollover resistance performance. However, because these devices do not prevent rollover (although there is an indirect effect), we should not evaluate rollover resistance simply by the existence of ESC. Honda believes that if a vehicle is offered with optional ESC or with ESC that has an “on/off” switch, that the vehicle must be tested with ESC “off”. Its base chassis should be evaluated.